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IMAGERY-ELICITING STRATEGIES AND MEANINGFUL LEARNING

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ABSTRACT

This paper reviews evidence that meaningful learning is facilitated by several imagery-eliciting strategies including pictorial stimuli, concrete verbal stimuli, and imagery instructions. The review focuses on the conditions under which imagery-eliciting strategies facilitate memory for prose or expository texts rather than for more simple paradigms such as word and paired-associate learning. Studies are included in the review which investigated the interaction of imagery-eliciting strategies with individual differences. Suggestions are made for improvement of research in the area.

Imagery-eliciting Strategies and Meaningful Learning

This review focuses on the conditions under which learning strategies involving imagery facilitate memory for instructional materials. The emphasis is on studies which involve meaningful learning tasks such as prose learning or learning from expository texts although investigations within other paradigms such as paired-associate and word learning are briefly discussed to provide a framework. The review is organized around the main types of imagery-elicitng strategies including (1) pictorial stimuli such as pictures, graphs, etc.; (2) concrete verbal stimuli; and (3) imagery instructions or direct inducements. Following the review is a summary and discussion of imagery effects.

Theoretical Conceptions of Imagery

There is a great deal of controversy over the validity and usefulness of the imagery construct in understanding and explaining human cognition. Various theoretical models or conceptions of cognition attempt to account for the empirical findings about pictorial and visualization strategies, making different assumptions about the role and the nature of imagery. Some theorists believe that imagery plays a central role in cognition (Bugelski, 1970; Paivio, 1971) while others see amodal data structures (rather than stored images and words) as the elements of knowledge (Anderson & Bower, 1973; Norman & Rumelhart, 1975; Pylyshyn, 1973). A problem with comparing and contrasting the various

theories is that they may simply be different ways to discuss different issues related to cognition rather than alternative, testable models about the same phenomenon. That is the problem with the current "images versus data structures" debate according to recent reviewers (Yuille & Catchpole, 1969). They accuse theorists of confusing knowledge with its representation in the argument about pictorial and verbal forms of knowledge versus the nature of basic information storage units. Other reviewers concur that due to a fundamental indeterminancy, the so-called alternative models can predict and account for the same experimental findings (Anderson, 1978; Kosslyn & Pomerantz, 1977). Despite the lack of meaningful distinction between the approaches, the two basic conceptions of imagery are briefly described to provide a context for the empirical findings concerning imagery.

The dual-code model of imagery is so named because it asserts that there are two independent systems of cognition: verbal-abstract and imaginal-concrete. The main proponent of this model is Paivio who has presented his dual-coding hypothesis in several publications (e. g. Paivio, 1971, 1974, 1975). According to the dual-code model, words and pictures are perceived and stored separately from one another with the imagery system "specialized for processing non-verbal information stored in the form of images.... (which) are analogue representations of perceptual information" (Paivio 1975, p. 145). Paivio postulates a

"coding redundancy" hypothesis to explain how the dual-coding model accounts for imagery effects on learning and memory. Encoding a stimulus in both systems will make it more memorable than if the stimulus elicits only one code. Paivio explains this notion: "The problem of remembering an item would thus be a direct function of the availability of both codes. In effect, this is a coding redundancy hypothesis." (1971, p. 181).

The amodal theorists such as Anderson and Bower (1973) and Pylyshyn (1973) maintain that the structure of knowledge is propositional, consisting of data structures which are more basic than either pictures or words. Pylyshyn states the case for the amodal approach, arguing that "the need to postulate a more abstract representation--one which resembles neither pictures or words and is not available to subjective experience--is unavoidable. As long as we recognize that people can go from mental pictures to mental words and vice versa, we are forced to conclude that there must be a representation (which is more abstract and not available to conscious experience) which encompasses both" (Pylyshyn, 1973, p. 5). Data structures theorists contend that perceptual descriptions are stored as inferential conclusions and that "the only difference between the internal representation for a linguistic input and a memory image is detail of information" (Anderson and Bower, 1973, p. 460). It is not really clear why detailed information would be the more memorable type, however.

A schema-theoretic model of cognitive processing may provide a better explanation of imagery effects from a data structures viewpoint. The extreme form of the propositioal data structures model, which assumes that all representations in memory are abstract, is not compelling or consistant with evidence linking imagery and perception (Shepard, 1978). Palmer (1975) gives a detailed account of how propositions or schemata are capable of encoding an analogy image so that the distinction between imagery and data structures becomes meaningless.

The explanation of imagery effects in schema-theory terms is based on the distinctiveness or specificity of images. Empiricial evidence links picture effects to the variable of distinctiveness. Pictures that look alike are not remembered better than their verbal counterparts while pictures that look quite different are remembered much more easily than their verbal equivalents even when the pictures are conceptually related (Nelson, Reed, & Walling, 1976). It is noteworthy that although distinctiveness may make an image more retrievable, we can't conclude that the words have been "forgotten." People don't forget common words following a word-learning experiment but they do often forget which particular words were encountered in a particular experimental situation. The words correspond to general schemata or data structures according to schema theorists and are certainly not unmemorable per se.

A schema has been described as a stereotyped concept

and has been likened to a play having a script with roles that need to be assumed (Rumelhart & Ortony, 1977). A schema is activated by a particular instance of a concept just as a play is enacted with particular actors. The general schema for a common word is not forgotten after a word-learning experiment, but the learner may not be able to retrieve a particular instance of the schema similar to not being able to recall a particular enactment of a play. Another useful analogy for a schema is a compter program. A program has parameters which take on certain values as the program is executed. To carry on the analogy, a new schema is created or an existing shchema is activated (the program executes) when a learner encounters information. In the case of picture perception, the learner probably has to create a new schema because there are no existing schemata that are closely related enough to account for the data (see Bobrow & Norman, 1975). In creating a new schema, all of the parameters of the schema are set to the specific values corresponding to the particular situation and this filling-in process is called "instantiation" (see Rumelhart & Norman, 1976). Frequently used schemata such as those for common words are constantly updating and adjusting their parameters to align with the "default case" which is the general case or stereotype of the schema (see Palmer, 1975; Reese, 1977). During verbal processing, a person probably activates only the stereotypic schemata for the words encountered and does not create fully-instantiated copies of

the general schemata for the particular instances encountered. Therefore, the specific schemata are not retrievable because they were never created. Again, the person still "knows" the words and has certainly not lost or forgotten the schemata for them. Mental images, on the other hand, are quite memorable because particularized schemata are instantiated during processing and are not modified during subsequent mental activity due to their distinctiveness. The feature of distinctiveness makes it unlikely that similar stimuli will be encountered that will cause the parameters to align with the stereotypic case. For this reason, imagery is more memorable than verbal material according to schema theory which the author finds a credible, though admittedly untestable, explanation.

Despite the purported differences between the dual-code and data structures models in terms of the nature and role of imagery in cognition, neither model adequately defines the construct of mental imagery or accounts for the empirical results of imagery-eliciting strategies. As Anderson (1978) has pointed out, most researchers and theorists agree that there is a phenomenon called mental imagery, but the disagreement centers around defining the imagery construct. The concept of mental imagery as a phenomenon is viable (Shepard, 1978), however, and provides a way to organize and discuss the empirical findings related to the strategies discussed in this review.

Research on Pictures

Most researchers adopt the common dictionary definition of a picture, using their intuition to identify pictorial material. Here, pictorial material (also referred to as a picture or an illustration) is defined as any relevant, two-dimensional representation in which the stimulus array contains at least one element that is not alphabetic, numeric, or arithmetic.

Illustrations should be conceptually related in some way to the topic of the communication since unrelated or inaccurate pictures can have adverse effects on memory (Peeck, 1974). Unfortunatey, some studies tested picture effects with unrelated illustrations or with pictures that portrayed a very small amount of the material to be learned. For example, the "related picture" condition in one study consisted of associates rather than equivalents so that a picture of a dog accompanied the word "cat" (Willows, 1978). Children in that study "knew that the pictures were there to distract them," and so, not surprisingly, they made more word-naming errors in the picture condition than in a word-only condition. The experimenter concluded that pictures function as distractors in reading. Other researchers used pictures merely as embellishments (Baker & Popham, 1969) or to illustrate only a small portion of the to-be-learned material (Vernon, 1953; 1954) and concluded from the lack of a main effect that pictures do not facilitate learning. A facilitative effect for pictures was actually found in Vernon's studies when only picture-related text was

considered. The type of pictures used in these studies reveals some basic problems with picture research that are discussed later in this section.

Imagery-eliciting strategies fall into two broad categories including experimenter-provided and subject-generated strategies. Levin (1977) has termed this classification the imposed-induced dichotomy. For pictures, an imposed strategy refers to showing the learners pictorial material prepared by someone else while an induced strategy refers to learners drawing or generating their own graphics. Studies are grouped according to this classification.

Imposed Picture Effects

Research on experimenter-provided pictures includes studies that tested the effects of (1) supplanting (i. e., replacing) verbal information with pictures or (2) supplementing (i. e., repeating) verbal information with pictures. The research findings are organized by this supplementing-supplanting distinction as well as by the type of learning task--namely, single items, paired associates, and meaningful learning. The last category is of greatest interest and involves the learning of prose material or expository text. School learning often involves expository text which consists of concepts that are new to the student.

Supplantation. A number of studies reviewed by Paivio (1971) compared memory for pictures to memory for words and found that pictures are remembered better than either concrete words or abstract words. More recent studies have

confirmed the pictorial superiority effect (see Paivio & Csapo, 1975) and found that memory for pictures actually increases rather than decreases over time (Erdelyi & Becker, 1974). Pictorial presentation has not proven facilitative in concept identification, however (Katz & Paivio, 1975).

It may be inappropriate to attribute memory differences to the factor of mode when picture memory is compared to word memory because mode may not be the only varying factor between words and pictures. The verbal equivalent of a picture is probably not a single word but rather a story or description. Since memory for words in context (i. e. a story) is better than for an unconnected word list (Pompi & Lachman, 1967), spatial memory may not surpass verbal memory if the two modes of information are equated for amount of informational content. One study found no effect for mode when the factor of schematic similarity was controlled (Nelson et al., 1976). In that study, the superiority of visual memory was traced to schematic dissimilarity among the pictures to be remembered. Pictures that were graphically similar were not better remembered than their verbal counterparts. If pictures are memorable because they are physically distinct or unique, then pictures that are especially distinct, unusual, bizarre or unique should be most memorable, but research has not confirmed this hypothesis (see review by Higbee, 1979). Incongruent, complex, or unique pictures do attract more attention, however (Mannally, Faw, & Bashford, 1969).

Despite uncertainty about the underlying causes of the effect, many studies have demonstrated that supplanting words with pictures facilitates item learning and memory (Pavio 1969; 1971). Supplanting verbal material with presumably equivalent graphics also appears to facilitate meaningful learning although findings are not totally consistent. One study that compared all-verbal to verbal-pictorial presentation found that experimenter-provided graphics aided retention in college students (Rigney & Lutz, 1976a). Students in that study saw informationally-equivalent versions of a computer-assisted instruction lesson about a topic in science, presented either with animated graphic analogies or equivalent verbal descriptions. Students in the graphics condition learned more and had more favorable attitudes as well. A study by Booher (1975) showed that both supplementing and supplanting verbal information with pictures facilitated three types of perceptual-motor tasks for Navy personnel. The results suggest that pictures facilitate speed of performance while printed words aid accuracy of comprehension.

When pictures completely replace the verbal text, however, comprehension (as assessed by a verbal posttest) may not be facilitated. One researcher reported that adults in a developing country misunderstood information presented pictorially although inadequate design and control prevent the researcher from making any valid conclusions (Spaulding, 1956). High school students in a number of developing

countries learned best when material was presented both pictorially and verbally rather than in only one mode or the other (Jahoda et al., 1976). Lack of a main effect for pictures in that study, however, may be explained by the fact that the dependent measure was specifically designed to test for information presented only in one or the other version, thereby favoring learners who saw both versions.

Studies with children reveal similar results when pictures completely replace the verbal text. In an early study using stories and pictures from a basal reader series, second graders did better on a verbal multiple-choice test in a text-only or text-plus-pictures condition relative to a pictures-only treatment (Weintraub, 1960). Based on individual interviews with those second graders, the author noted that the children in the picture condition could "utilize the pictures to tell stories closely related to that written in the text, but there were nuances and delicate shades of meaning which apparently could not be gleaned from the pictures" (p. 59). Another interpretation is that the recall test assessed information presented only in the verbal treatment. In a more recent study, children who received a story in the form of a series of pictures remembered no more than students who read the printed text (Levin, 1973). Again, the explanation of these results could be that the verbal comprehension test failed to test the kind of knowledge acquired from an all-pictorial treatment. Several studies indicate that illustration may

result in graphic knowledge not assessed by a verbal test (Dwyer, 1972; Lutz & Rigney, 1977).

Supplementation. Most studies on pictures have tested the effect of supplementing verbal material with pictures. One basic methodological problem with the supplementation approach is that type of information is confounded with amount of information since groups given the text plus adjunct pictures are usually compared to groups given only the text. The better approach is to provide the control condition with equivalent verbal material while the treatment group sees the pictures (see Rigney & Lutz, 1976a) or to give the control group double exposure by repeating the verbal lesson (see Levin, Bender, & Lesgold, 1976). Studies using supplementary pictures without adequate controls are, nevertheless, included in the review since they may be more representative of real-world learning situations and thereby possess greater ecological validity (Snow, 1974).

There are many paired-associate learning studies which indicate that a supplementary picture helps the viewer associate the two words to be learned. Learners shown a picture relating two items in a paired- associate learning task typically have significantly higher retention scores than those not presented with a picture and told only to learn the association through repetition (Davidson, 1974; Kerst & Levin, 1973; Lippman & Shanahan, 1973; Lutz & Lutz, 1977; Reese, 1965).

Recent studies indicate that supplemental pictures also facilitate meaningful learning. A number of studies indicate that children from kindergarten through fourth grade learn more from a prose passage presented orally when it is accompanied by pictures (Dunham & Levin, 1979; Guttman, Levin, & Pressley, 1977; Lesgold, Levin, Shimron, & Guttmann, 1975; Levin et al., 1976; Peng & Levin, 1979; Rohwer & Harris, 1975; Rohwer & Matz, 1975). This picture effect endures over time (Peng & Levin, 1979) and facilitates learning of educable mental retardates (ages 10-16 yrs) (Bender & Levin, 1978). These studies of prose learning used pictures that completely overlapped the text content and that were presented along with the text. The picture effect may not occur under other conditions. For example, presenting pictures during the testing phase did not facilitate test performance for third graders (Ruch & Levin, 1977). Also, there was no facilitation for text content which was not illustrated by the supplemental picture while an 86% facilitation occurred for content which was illustrated (Dunham et al., 1979).

Illustration also tends to aid children's memory for more difficult material that contains new concepts. DeRose (1976) found that pictures aided fifth-grade students' memory for a social studies text passage compared to a read-only control and to a subject-generated imagery condition. The strategy aided memory only for those concepts that were depicted graphically; that is, there was no effect on recall

of text information that was unrelated to the supplemental pictures. Supplementary pictures also helped fourth and fifth graders learn math concepts (Rasco, Tennyson, & Boutwell, 1975). Pictures even helped fifth graders learn social studies and science facts under incidental learning conditions when presented as part of a spelling and grammar exercise and unexpectedly tested for (Goldberg, 1974). Illustrations can also facilitate retention in children when the graphics are presented prior to the verbal information. Eighth-grade students remembered more information from an 1100-word passage on continental drift when the passage was preceded by an appropriate map or graph than when preceded by an abstract, 500-word passage on the topic or by no prior material (Weisberg, 1970).

The effectiveness of a picture strategy may vary with learner ability according to findings by Wardle (1977). Seventh graders in her study who were below the median reading level benefitted from an illustration presented in a science lesson. There was no main effect for picture presentation perhaps because a) only one illustration supplemented the 800-word passage, and b) two of the three picture conditions saw a picture that had either low or medium relevance to the passage. Other studies on children's learning have investigated the interaction between pictorial presentation and individual differences with mixed results. Rohwer and Harris (1975) report that low-SES children learn more from a combination of verbal and

pictorial modes while high-SES children do not. Using modified versions of the passages from that study, another experiment revealed a facilitative effect for pictures across ability levels (Rohwer & Matz, 1975). In that study, a visual inspection of the data suggests that low-SES fourth graders benefitted more from pictures than print to a greater degree than high-SES children, but the differential effectiveness of pictures was not statistically confirmed. A similar pattern of results was found in a study mentioned earlier by Levin (1973). Poor readers tended to learn more from pictures than words to a greater degree than good readers but, again, this was not a significant interaction effect. Several studies with seventh grade children in Sweden suggested similar results with expository text. Gustafsson (1974; 1976) reports that pictorial instruction is best for students with high spatial but low verbal ability while verbal instruction is best for learners with high verbal and low spatial ability. Although the findings were not totally consistent, students with low verbal ability generally benefitted more from the pictorial treatment. Gustafsson also found several main effects for graphic presentation such that supplementary pictures helped learners of all ability levels. Although there is no clear, empirical support for an interaction effect for pictures with ability, the data do allow speculation that highly verbal children do not benefit from seeing pictures as much as children with lower verbal ability. Improvements to

aptitude-by-treatment interaction (ATI) research have been suggested (Cronbach & Snow, 1977) so that future investigations may yield more consistent and elucidatory results.

The picture strategy may not be as effective for prose learning by adults. College students who read a passage about revolutions with supplementary pictures remembered more than learners in a read-only control condition (Rasco et al., 1975). However, the strategy of mental imagery instructions appeared to be more effective than the picture strategy. A second study suggested a similar pattern of results with high school seniors but no significant effects were observed. The lack of a strong picture effect in these two studies could be due to the fact that the drawings did not depict all of the content in the 2511-word passage but only "the more salient ideas in each paragraph". More likely, the content may have been so easy to read and comprehend that the adult readers just ignored the supplementary pictures.

Supplemental pictures do appear to help adults and high school students learn new concepts from expository text. Arnold and Dwyer (1975) found that pictorial supplementation of verbal information about the physiology of the heart resulted in better performance by high school students on a verbal retention test. A similar study conducted with college students also demonstrated the benefits of illustration (Dwyer, 1972). In that study, pictures aided

performance on a drawing test and on overall performance but not on several verbal learning measures, indicating that pictures affected nonverbal outcomes. Similar findings are reported by Dwyer (1970) for a number of earlier studies. Finally, a more recent study with science materials found that diagrams helped high school students learn new concepts (Holiday, 1975). The pictorial materials used in all of these studies varied on a variety of dimensions that may have affected the results. The importance of various picture characteristics are discussed in a later section.

Induced Picture Effects

Research on pictures indicates that learning is also improved when learners are asked to draw their own illustrations. Subject- generated pictures facilitate paired-associate and word learning (see Bull & Wittrock, 1973), story comprehension and recall of new concepts. In one study, college students who had to illustrate prose passages performed better on a criterion test than a control group and also performed as well as students who answered inserted questions (Snowman & Cunningham, 1975). However, students in the drawing condition spent appreciably more time than the control group so that group difference could be attributable to time differences. In another study, college students remembered a prose passage better when they spent five minutes illustrating the passage after reading it (Lesgold, Levin, et al., 1975). The passages varied from abstract to concrete but the drawing factor did not interact

with passage concreteness. Control subjects spent the five minute intervals either drawing unrelated figures or alphabetizing the words in the passage so that experimental subjects in this study also spent more time with the content. Time differences could again account for the group differences, which disappeared on the delayed retention test given one week later.

There are several studies which tested the effects of a drawing strategy with better control over time spent by those who drew and by comparison groups. After receiving extensive training in imagery and drawing, adults performed better on a delayed retention test than learners who received no strategy training (Dansereau et al., 1975). Even with short directions rather than extensive strategy training, college students who were told to draw pictures (including analytic or holistic pictures) to illustrate science concepts performed better on the posttest than a read-twice control group (Lutz, 1979). In comparison to a group using a verbal learning strategy, however, learners who illustrated science concepts did not perform as well (Tirre, Manelis, & Leicht, 1979)

Children 8 years old and older can also benefit from a drawing strategy according to findings by Rasco, Tennyson and Boutwell (1975). Fifth-grade students in their study remembered more about a passage on arithmetic concepts when they drew pictures to illustrate those concepts compared to a read-only control. In another study, third and fourth

graders benefitted from training in how to illustrate prose passages (Lesgold, McCormick & Golinkoff, 1975). Some children were trained to portray every picturable fact from a passage while the control group participants were trained to read passages and answer multiple-choice questions. Children who had received the prior illustration training benefitted from instructions to use mental imagery when reading a prose passage while control subjects did not benefit from imagery instructions.

An induced picture strategy has not always proven useful with young children. First graders were not able to illustrate a story by selecting and arranging appropriate pictorial components from a large pool of cutouts (Lesgold, Levin et al., 1976). However, the children did benefit from constructing a picture from the cutouts when only the appropriate pieces were provided to them. Another study that involved a task which bridges the gap between imposed and induced strategies was done with college students (Rigney & Lutz, 1976b). After studying a CAI lesson on how a battery works, learners in that study remembered more information if they constructed a model of a battery using pictures of components and processes provided on the CAI system. Few studies have investiaged tasks that require the learner to manipulate or rearrange experimenter-provided graphics but such tasks seem potentially rewarding.

Discussion of Picture Effects

Levin and Lesgold (1975) reviewed studies in which

pictures facilitated prose learning under the following five conditions; 1) the prose passages were presented orally; 2) the subjects were children; 3) the passages were fictional narratives; 4) the pictures overlapped the story content; and 5) learning was demonstrated by factual verbal recall. The studies reviewed here extend these conditions considerably although methodological flaws in picture studies to date preclude making firm generalizations at this time. However, the studies reviewed here suggested that seeing or drawing relevant pictures facilitates learning in both children and adults of all ability levels for all types of material, not just prose passages presented orally. Pictures also facilitate non-verbal learning outcomes perhaps more so than verbal, factual recall. But pictures must be relevant to the instructional topic and the information assessed by the posttest for the picture effect to occur.

Picture Characteristics. While the commonality of the studies reviewed in this section is that they all investigated picture effects, the treatment conditions differed considerably across studies. The pictorial materials used in these studies varied on a number of dimensions such as realism, color, motion, size, complexity, and media vehicle. For example, most of the pictures were stylized, line drawings (see most of the studies by Levin and his associates) while others were realistic, shaded drawings, paintings, or photographs (see Dwyer, 1970). Most

pictures were black and white but some materials had one additional color (see Spaulding, 1956) or were in full color (see Dwyer, 1972). Most visuals were static but a few were animated (see Rigney & Lutz, 1976a). The presentation conditions also varied widely. Most pictorial stimuli were presented once for a brief duration (single exposure), but some were cumulative pictures that were viewed throughout the learning session (see Rohwer & Matz, 1975). Most pictures were presented for viewing along with the orally-presented verbal information while some preceeded the text (see Weisberg, 1970) and some followed it (see Lesgold, Levin et al., 1975). Research studies aimed specifically at investigating some of these picture characteristics have not conclusively linked any of these picture attributes to the facilitative effect of pictures.

One critical variable that has been identified is relevance of the picture to the verbal information and test items. Verbal information supplemented by relevant pictures is recalled better than unsupplemented verbal text for prose (see Dunham & Levin, 1979) as well as expository text (see DeRose, 1976). Unfortunately, few investigators thoroughly described the relationship of the pictorial stimuli to the verbal information and test items. However, it appears that the variance among studies is considerable in terms of the number of pictures used and the level of picture relevance. For example, researchers report using one picture to illustrate each concept or sentence (see Guttman et al.,

1977), one picture to illustrate each paragraph (see DeRose, 1976), several pictures per lesson (see Vernon, 1955) or one picture per lesson (see Wardle, 1977). It is noteworthy that despite this variability among studies, the facilitative effect of the pictorial strategy has been demonstrated rather consistently.

Generalizability of Picture Effects. A number of studies investigating picture effects have, unfortunately, used unrepresentative or unrelated pictures and over-generalized their results. Changes in experimental design, procedures, and analysis are needed to achieve valid, generalizable results. Studies on picture effects should use a sample of pictures and treat materials as a factor. Snow (1974) has pointed out the necessity of obtaining a representative sample of situations as well as subjects, but no studies involving meaningful learning have randomly sampled pictures from some identified population. Instead, most studies on picture effects used experimenter-constructed pictures. Only a few studies drew pictures from an environmental source such as a published textbook, magazine etc. (see Lutz & Lutz, 1977; Vernon, 1954; Weintraub, 1960). One exemplary study that properly sampled pictures is a study of picture characteristics by Fleming (1967) in which he randomly selected six percent of the illustrations in 40 textbooks yielding 787 pictures for the investigation.

Pictorial materials should not only be sampled but

should be treated as a random, nested factor so that any effects on learning by other factors such as mode of materials can be generalized beyond the specific materials used in the study. Treating materials as a random rather than fixed factor has been suggested by Clark (1973), who proposes using "quasi" F-tests which treat variance due to the materials factor as error variance. Such a procedure tests the effects of any crossed factors after taking into account the effects of the specific materials used so that treatment effects due to, for example, mode of materials are not erroneously over-inflated. Using several sets of materials and analyzing the results as Clark suggests should strengthen studies on picture effects.

Research on concrete verbal stimuli

The second main type of imagery strategy that has been investigated is concreteness or "imagery value" of verbal material, which refers to the ease with which a word elicits a mental image. Imagery values for hundreds of words have been established by having readers rate how well a word arouses sensory images. These ratings are available for nouns (Paivio, Yuille, & Madigan, 1968), for verbs (Lippman, 1974), and for words frequently used by children (Van der Veur, 1975). Some researchers have distinguished between concreteness and imagery-evoking value of words by limiting concrete words to those that can be experienced by the senses. According to that definition, a word like ghost would have a high imagery value but a low concreteness

value. However, the two terms--concreteness and imagery value--are used interchangeably in this review.

Research findings concerning the effects of imagery value of verbal stimuli generally indicate that concreteness facilitates memory for words, paired-associates, and narrative or expository text. Studies will again be grouped around these three stimulus categories.

Paivio (1969, 1971) reviewed the effects of concreteness or imagery value on word recall. He cited a series of experiments that independently varied imagery and other factors that influence word memory such as meaningfulness and found that word recall was positively related to the level of word concreteness. Recent evidence confirms that concreteness facilitates word learning for both adults and children (Wittrock & Goldberg, 1975). Concreteness effects have even been found with blind learners when the words referred to concrete auditory rather than visual referents (Paivio & Okovita, 1971).

Concreteness also facilitates paired-associate learning. When words are to be associated, memory for the pair can be facilitated by giving the learner concrete connective words. Several studies varied the kind of connective words used to relate word pairs and found that verbs were more effective in facilitating memory for the pair than conjunctions or prepositions (Reese, 1965; Rohwer, Lynch, Levin & Suzuki, 1967). Although imagery values for the connecting words were not compared, it seems quite

likely that the verbs had much higher imagery values than either the conjunctions or the prepositions used in those experiments. Embedding the word pair in the context of a sentence also aids memory for the pair (Davidson, 1964; Levin, Davidson, Wolff & Citron, 1973; Lippman & Shanahan, 1973; Milgram, 1967). It may be noteworthy that the sentences used in those studies related the word pairs primarily with action rather than stative verbs, since a visual inspection of Lippman's tabled concreteness values suggests that action verbs are more concrete than stative verbs.

Although a number of experiments have used sentences, passages, and texts to study various aspects of concreteness effects, only a few studies have investiaged the effects of concreteness on meaningful learning. Most of the studies tested response latency and recognition rather than recall in order to investigate how people encode, store, and retrieve concrete versus abstract sentences. Concrete sentences which referred to real-world knowledge were verified faster than abstract sentences (Jorgensen & Kintsch, 1973). After reading prose passages that were either concrete or abstract, adults were quickly verified statements from the concrete version (Just & Brownell, 1974). Other studies have tested readers' ability to detect changes in concrete versus abstract sentences after reading a passage. Begg and Paivio (1969) found that meaning changes were more easily recognized in concrete sentences

while wording changes were easier to detect in abstract sentences. Although their study has been criticized for confounding the factors of comprehensibility and concreteness of the materials, several other studies have found that people detect meaning changes better in concrete than in abstract sentences with comprehensibility controlled (Johnson, Bransford, Nyberg, & Cleary, 1972; Moeser, 1974).

Studies of recall have investigated the role of concreteness in learning and memory. Concreteness correlates highly with recall for experimenter-constructed sentences (de Villiers, 1974) as well as for published expository text segments (Johnson, 1974). Several researchers manipulated concreteness by constructing sentences and passages which varied on the dimension of concreteness and tested the effects of the manipulation on recall. Sentences which contain concrete adjectives and modifiers were recalled better by adults than sentences redundantly modified (Anderson, 1974) or than sentences containing "dull" adjectives (Kirchner, 1969). Concrete versions of prose passages were better remembered than otherwise equivalent, abstract passages (Montague & Carter, 1973; Yuille & Paivio, 1969). The relevance of these studies to meaningful learning are limited, however, because the materials were contrived and the dependent measures used were simply the number of words recalled and type of words recalled.

The results of a recent study provide more encouraging

evidence that concreteness facilitates meaningful learning (Tirre et al., 1979) In that study, the passages were sampled from textbooks on several topics in science. Independent ratings indicated that the expository passages were equivalent in terms of comprehensibility but differed on the concrete-abstract dimension. The concrete passages were comprehended better than the abstract passages according to a short answer test although concreteness did not affect scores on a verbal, multiple-choice test. Unfortunately, the study has two main flaws: a) concreteness was confounded with the passages factor (subject-matter differences between the passages) and b) concreteness was a within-subjects factor so that prior exposure to a concrete passage could have caused the reader to use more mental imagery when subsequently encountering a more abstract passage. Despite the limitations of this and other studies, there is a consistency in the evidence which suggests that concreteness is a useful facilitative strategy.

Research on imagery instructions.

The two types of strategies discussed so far are external stimuli that presumably elicit internal or mental imagery. Giving instructions to the learner to form mental imagery is a more direct way to elicit this type of mental processing. Imagery instructions refer to a statement to the learner that directs him or her to form a mental picture of the concept to be learned.

The effects of mental imagery instructions on word learning and paired-associate learning are reviewed and discussed elsewhere (Higbee, 1979; Paivio, 1971; Pressley, 1977) and will be only briefly summarized here. Giving learners imagery instructions facilitates paired-associate and word learning and the effects are much like those reported in the previous section on pictures. The interactive feature of the mental image remains a necessary condition for maximum effectiveness. Learners told to mentally image two objects in interaction remember more word pairs than learners told to mentally picture the objects side by side or on opposite sides of a room (Bernback & Stalonas, 1973; Bower, 1972; Weisser & Kerr, 1973).

One advantage of mental imagery, as opposed to experimenter-supplied interactive pictures, is that mental images may be idiosyncratic and bizarre, as recommended by ancient as well as modern day mnemonists (Lorayne & Lucas, 1974). The claim that bizarre images facilitate memory has not been empirically supported, however (Higbee, 1979). In

fact, students may take longer to form bizarre mental images than "common" images with no corresponding gains in learning.

Recent findings indicate that imagery instructions also facilitate memory for more meaningful materials. Children remember a passage better when they receive imagery instructions, especially if the instructions are preceded by training in the use of this strategy. Fifth-and sixth-grade children remembered more from a prose passage when they received instructions to form mental pictures of the passage contents (Kulhavy & Swenson, 1975). Prior training in imagery or picture generation can enhance the effect of imagery instructions on prose learning according to several recent studies. An experiment mentioned earlier (Lesgold, McCormick, and Golinkoff, 1975) found that imagery instructions were more effective for a group that received four weeks of training in illustrating every pictureable fact of a prose passage. The assumption in that study was that training in external pictorial mediation (i. e. drawing) would facilitate the learners' ability to generate internal imaginal mediators. Pressley (1976) challenged that assumption and gave his students much shorter training that was directly relevant to the task. During the training session, third-grade students either practiced making up mental images and were shown examples of good pictures or practiced recalling story facts. Students who received imagery training were then instructed to form mental images

after reading each passage of the target text. This group remembered more about the passages than the control students who received no imagery training and no imagery instructions. Unfortunately, we cannot conclude from this study whether the experimental group's superior performance is attributable to the imagery training, imagery instructions, or combination of the two treatments.

The effects of imagery instructions are not consistent for children's learning of expository test. Fifth graders who were told to mentally imagine the concepts presented in a 490-word social studies passage did not remember as much content as learners shown relevant pictures and did no better than control group learners (DeRose, 1976). These results could be due simply to the nature of the passage used in the DeRose study. Imagery instructions facilitated learning for sixth graders relative to a read-only control when 16 randomly-sampled passages from science, reading, and social studies textbooks were used (Gagne & Memory, 1978). The findings from this study provide strong evidence that mental imagery facilitates children's learning for a variety of subject matters.

Individual differences may interact with imagery instructions in children's learning. Fourth-graders classified as pictorial learners remembered more from a prose passage than non-pictorial learners when given imagery instructions (Levin, Divine-Hawkins, Kerst, & Guttman, 1974). However, without the imagery instructions, retention

was not related to individual differences in learner type. The findings suggest that picture learners benefit from imagery instructions while verbal learners do not. In fact, imagery instructions appeared to have a detrimental effect on reading comprehension of those children who were not picture learners.

The effectiveness of imagery instructions also varies with the age or developmental level of the child according to recent reviewers (Levin, 1976; Pressley, 1977). Young children such as kindergarten and first grade students benefit from seeing pictures but not by being told to generate mental imagery whereas older children benefit from both imposed and induced strategies. For example, Shimron's work (1974) suggested that imagery instructions helped fourth graders but not first graders remember prose passages. More recently, researchers have confirmed the superiority of a completely imposed strategy (pictures) compared to a completely induced strategy (imagery instructions) for young children but further demonstrated that young children can benefit from a combination imposed-induced strategy--partial pictures that provide strong cues to generate imagery (Guttmann et al., 1977).

Adults also learn better using mental imagery. Imagery instructions facilitate memory for easy material such as sentences and narratives (Anderson, 1971; Anderson & Hidde, 1971; Rasco et al., 1975). Imagery instructions per se appeared to have no effect on memory in one study, but

closer examination reveals that mental imagery did facilitate learning (Anderson & Kulhavy, 1972). Students in that study who reported that they learned the text passage by using "mental pictures" remembered more than students who reported not using mental imagery. The findings of this study are important because, while the nominal treatment of imagery instructions may fail to elicit mental imagery, actual use of mental imagery (per self-report) does correspond to increased recall. Another study showed no overall benefit from imagery instructions during a limited time period (Lesgold, Curtis, DeGood, Golinkoff, McCormick & Shimron, 1974). However, adults who received the imagery instructions remembered more from the first half of the passage than did control subjects, suggesting that the imagery strategy required more time but was beneficial. The authors, however, felt that imagery should not be considered a useful strategy if it produces no learning gains per unit time.

Directing adults to use mental imagery while learning new concepts may not facilitate the learning of new, scientific concepts (Lutz & Rigney, 1977) or the solving of insight problems (Wicker, Weinstein, Yelich, & Brooks, 1978) although long term retention of the science concepts may be enhanced (Dansereau et al., 1975). The failure of mental imagery instructions to aid new concept learning in both adults and children is plausible because we cannot expect people to form mental images of concepts which they don't

already know.

Discussion of Mental Imagery Effects. Although many studies showed that imagery instructions facilitate learning for older children and adults, the effects are not very striking in comparison to the large gains produced by giving the learner pictures or concrete language. For example, imagery accounted for only 6% of the variance in one study (Pressley, 1976) and produced only a 13% learning gain in another (Lesgold, McCormick, et al., 1975). For some populations such as educable mental retardates, mental imagery has not proven facilitative at all (Bender & Levin, 1978). In general, however, mental imagery facilitates meaningful learning which may be especially helpful to learners who are not verbally inclined.

One problem with trying to induce the learner to use mental imagery while reading is that the act of reading tends to interfere with imagery production, because both activities presumably involve some visual information processing. One study found that imagery instructions were more facilitative when children listened to a passage rather than read it (Levin & Divine-Hawkins, 1974). Also, mental imagery was more readily elicited during listening than during reading by adults (Brooks, 1967). In some of the studies reviewed here, learners visualized while reading, so that imagery effects may have been stronger if the learners had listened to, rather than read, the verbal information. Many of the studies with children, however, involved orally-

presented text. One study alternated printed and blank pages in the study booklet and instructed learners to first read the passage and then turn to subsequent blank page and "make up a picture in your head of what you just read" (Pressley, 1976). The performance of the imagery group was superior to the control but no comparison was made between spaced versus simultaneous imaging. That factor remains a question for future empirical reseach.

Summary and Discussion of Strategy Effects

The research cited in this review provides evidence that the imagery-eliciting strategies of pictures, concreteness, and imagery instructions generally facilitate meaningful learning for a variety of learners across a number of conditions. The three strategies differ according to the amount or degree of external support that they provide for the learner with pictures providing the most support, concrete language providing less support, and imagery instructions requiring a learner-generated rather than provided strategy (cf. Rohwer, 1973). There appears to be a correspondence between degree of external support and facilitative effect across all types of learners although the pattern is more pronounced for some learners. Pictures were more effective than imagery instructions in learning expository text (DeRose, 1976) and in prose learning (Dunham & Levin, 1979) for children. For young children, the picture superiority effect is even greater because they are apparently unable to construct their own

mediating images upon demand (Shimron, 1974) but can generate mental imagery in response to strong visual cues (Guttmann et al., 1977). In the latter study, dynamic partial pictures elicited facilitative mental imagery in first graders. This success suggests that the failure of young children to benefit from a completely induced strategy such as imagery instructions is due to their inability to generate appropriate or relevant images rather than an inability to form mental images per se. Recall the study by Lesgold, Levin, Shimron and Guttmann (1975) in which first graders were not able to select the appropriate pictorial elements from a large pool to illustrate a story but benefitted from constructing an illustration when only the appropriate pieces were provided to them. More studies are needed to test the effects of strategies that provide a successively smaller degree of external support until the learners can generate their own strategies.

Although a main effects interpretation of imagery effects is indicated, these strategies--especially when imposed--may be particularly helpful for non-verbal learners or other types of disadvantaged learners. The evidence suggests that although there is a main effect for pictures across learner types, pictures are more beneficial to non-verbal learners (see review by Gustafsson, 1974). Disadvantaged youngsters may benefit more from seeing pictures than do other children (Rohwer & Harris, 1975). And finally, retardates can benefit enormously by seeing

relevant pictures--with up to an 89% facilitation for pictures--while imagery instructions may not help this population (Bender & Levin).

The effects of imagery-elicitng strategies on meaningful learning are fairly durable over time for pictures (Peng & Levin, 1979), concreteness (Tirre et al., 1979) and imagery instructions (Kulhavy & Swenson, 1975). The facilitative effects hold not only for factual recall (knowledge of lesson contents) but also when assessing comprehension and application levels of cognitive outcomes for pictures (Rigney & Lutz, 1976a), concreteness (Tirre et al., 1979), and imagery instructions (Kulhavy & Swenson, 1975).

Finally, the facilitative effects of imagery-eliciting strategies may not be attributed simply to other factors such as rehearsal or increased semantic encoding. The study by Levin, Bender, & Lesgold (1977) demonstrated that pictures provide a facilitative effect beyond the simple rehearsal provided by seeing supplementary information. In that study, suplementary pictures were more effective than a repetition of the verbal text. Imagery effects may not be attributed simply to depth of processing or semantic encoding either. In a recent study, researchers tested the effects of imagery instructions while also manipulating depth of processing by inserting either paraphrased or verbatim questions in the learning session (Andre & Sola, 1976). If imagery involves greater depth of processing,

then the imagery treatment should have attenuated the depth of processing manipulation but no interaction occurred. Each factor facilitated recall independently. The facilitative effects of imagery-eliciting strategies on meaningful learning, that have been rather consistently demonstrated, cannot be attributed to any known factors and it remains the task of theoristists and researchers to develop and test a theoretical explanation of imagery effects.

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FOOTNOTES

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